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Changes in Visual Acuity, Axial Length, and Refraction After Removal of Intraocular Silicone Oil Following Retinal Reattachment Surgery in Chinese Patients: An Open-Label, Prospective Study

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ABSTRACT

BACKGROUND: As a vitreous substitute for long-term tamponade, silicone oil is widely used in vitreoretinal surgery to treat retinal detachment with proliferative vitreoretinopathy and some internal reconstruction after globe trauma.

OBJECTIVES: The aim of this study was to compare the changes in visual acuity, axial length, and refraction in eyes before and after removal of intraocular silicone oil of 2 different viscosities after retinal reattachment surgery. The difference in the final anatomic success (stable retinal reattachment) rate was also assessed.

METHODS: Patients with surgically reattached retinas were enrolled in this open-label, prospective, nonrandomized study. All patients underwent pars plana vitrectomy, lensectomy, scleral buckling or encircling, and epiretinal membrane dissection; silicone oil was removed after stable retinal reattachment was achieved. Refraction, axial length, final visual acuity, and stable retinal reattachment were assessed ≤2 days prior to surgery (baseline) and ≤1 month after silicone oil removal. Refraction was measured using an autorefractometer, and axial length was measured using A-scan ultrasonography, while visual acuity was assessed using a standard Snellen chart.

RESULTS: Of the 96 eyes assessed for inclusion, 89 eyes of 89 Chinese patients (mean [SD] age, 36.8 [4.3] years) were included in the study. Forty-two eyes (47.2%) were filled with 3700-centistoke (cS) silicone oil and 47 (52.8%) were filled with 5000-cS silicone oil. The mean interval between instillation and removal of the silicone oil was similar between the 3700-cS and 5000-cS groups (5.37 vs 5.10 months, respectively). The mean changes in visual acuity from before surgery to after removal of the silicone oil in the 3700-cS and 5000-cS groups were not significantly different (13/100 vs 15/100). The mean increase in axial length was also not significantly different in the 3700-cS group compared with the 5000-cS group (11.92 [1.97] vs 12.33 [1.28] mm). Mean decrease in refraction was significantly lower in the 3700-cS group compared with the 5000-cS group (5.80 [1.51] vs 6.88 [2.31] diopters; $t = 2.57$, $P < 0.05$). The anatomic success rate was 92.9% (39/42 patients) in the 3700-cS group and 91.5% (43/47) in the 5000-cS group.

CONCLUSIONS: A statistically significant decrease in refraction from baseline was found in the 3700-cS group compared with the 5000-cS group in these Chinese

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patients who underwent instillation and removal of silicone oil after retinal reattachment surgery. There were no other statistically significant differences between the 2 groups. (*Curr Ther Res Clin Exp.* 2009;70:221–227) © 2009 Excerpta Medica Inc.

KEY WORDS: silicone oil, axial length, refraction, viscosity.

INTRODUCTION

As a vitreous substitute for long-term tamponade, silicone oil is widely used in vitreoretinal surgery to treat retinal detachment (RD) with proliferative vitreoretinopathy (PVR) and some internal reconstruction after globe trauma.[1] Under the operating microscope, the vitreous body and all epiretinal and subretinal tractional components are removed. The retina is then reattached by applying liquid perfluorocarbon, endolaser, and/or cryotherapy. The perfluorocarbon is then exchanged for silicone oil or expanding gases to tamponade the retina. However, complications associated with long-term use of silicone oil, including cataracts, secondary glaucoma, keratopathy, and emulsification, have been reported.[2]

Despite progress in vitreoretinal surgery and the importance of silicone oil as an adjunct for the treatment of complex forms of RD, controversy remains about selecting oil with the proper viscosity for clinical use.[3] Evidence indicates that removing the silicone oil can increase the likelihood of significantly improved visual acuity in anatomically successful eye surgery.[4] The presumption is that completely filling the vitreous cavity with silicone oil is essential for converting the measured axial eye length and refraction.[5] To reduce adverse events, it is important to use silicone oil with the most suitable viscosity and to remove it once stable retinal reattachment has been accomplished.

The aim of this study was to compare the changes in visual acuity, axial length, and refraction in eyes after removal of intraocular silicone oil of 2 different viscosities after retinal reattachment surgery. The difference in the redetachment rate between the 2 viscosities was also assessed.

PATIENTS AND METHODS

Patients

This open-label, prospective study was undertaken in patients who underwent pars plana vitrectomy with instillation and removal of silicone oil by the same surgeon at Renmin Hospital of Wuhan University (Wuhan, China) between February 2005 and December 2007. Of these patients, we assessed data from those who met the following criteria: aphakia on removal of the silicone oil; intact iris and clear central cornea; pupil dilated to >5 mm; vitreous cavity filled ≥95%; retina completely reattached; silicone oil removed using the clear-cornea technique; and parameters measured ≤2 days before and ≤1 month after removal of silicone oil. Highly myopic eyes (≥–6.0 diopters [D]) and eyes with a redetached retina or an anterior chamber with silicone oil bulging through the pupil were excluded.

This was a nonrandomized study; the silicone oil viscosity used was based mostly on which oil was available in the operating room at the time of surgery (3700 centistoke [cS] or 5000 cS). Patients had a complete ophthalmologic examination, including

a visual acuity test (using a standard Snellen chart) and best corrected visual acuity, measurement of intraocular pressure, slit-lamp examination, autorefractometry, A-scan ultrasonography, and binocular indirect ophthalmoscopy both prior to and after silicone oil removal.

Visual acuity testing was conducted at each visit. Patients were asked to remove eyeglasses or contacts and to stand 20 feet from the eye chart. With both eyes open, the normal eye was covered as patients read aloud from the smallest line of letters they could see on the chart. If they were not able to see even the largest letter on the chart, the investigators asked the patients to determine hand motion. If this failed, patients were then asked to count fingers at 10 to 50 cm. If they were still unable to discern fingers, the last test was the perception of any light at all.

All cases were followed up for 8 months for development of possible complications and maintenance of retinal stability. The *anatomic success rate* (defined as stable retinal reattachment) was determined for both groups.

The current study was conducted with approval from the institutional review board of Renmin Hospital of Wuhan University and was performed in accordance with the ethical standards of the 1989 Declaration of Helsinki. The possible advantages and risks of the treatment were explained to all of the patients before surgery, and written informed consent was obtained from each patient.

Surgical Procedures

All eyes underwent pars plana vitrectomy using the standard 3-port technique[6] in combination with other procedures (lensectomy, scleral buckling or encircling, epiretinal membrane dissection, retinectomy, endophotocoagulation, and/or cryotherapy). In all patients, silicone oil* was manually instilled to replace the air, with the aim of completely filling the vitreous cavity, before an iridectomy at the 6 o'clock position was performed using a vitrectomy cutter.

The silicone oil was removed through the clear-cornea incision after stable retinal reattachment was achieved.[7] The corneal endothelium was coated with a viscoelastic material, and an anterior chamber infusion cannula was inserted into the limbus using a 3-mm diamond knife. Silicone oil is light and floats on water, allowing the infusion fluid to flow inside the eye. Silicone oil was expelled through the superior limbal incision. After removal of the majority of the silicone oil, repeated scleral tapping was done around the eyeball with a cotton-tipped applicator so that the small silicone droplets that had gathered below the central cornea could be easily and completely ejected through the clear-corneal incision.

Statistical Analysis

Statistical analysis was performed using SPSS software version 13.0 (SPSS Inc., Chicago, Illinois). The data were analyzed using the χ^2 and t tests to compare the findings before and after removal of the intraocular silicone oil.

*Trademark: Oxane HD® (Bausch & Lomb Incorporated, Waterford, Ireland).

RESULTS

A total of 96 eyes were assessed for inclusion; 7 eyes (3700-cS group, 3 eyes; 5000-cS group, 4 eyes) with retinas that redetached during follow-up were excluded from data analysis. Eighty-nine eyes from 89 Chinese patients (62 men, 27 women, mean [SD] age, 36.8 [4.3] years) were included in the study. Forty-two of the eyes (47.2%) were treated with silicone oil with viscosity of 3700 cS and 47 (52.8%) were treated with silicone oil with viscosity of 5000 cS. Of the operated eyes, 43 (48.3%) were right and 46 (51.7%) were left. Preoperative conditions included complex RD associated with PVR (43 eyes), macular hole RD (19), RD secondary to complications of proliferative diabetic retinopathy (12), giant tear RD (10), and RD associated with endophthalmitis (5).

The mean interval between instillation and removal of the silicone oil was not significantly different between the 3700-cS and 5000-cS groups (5.37 vs 5.10 months). The mean length of follow-up was 8 months in each group. The anatomic success rate was 92.9% (39/42 patients) in the 3700-cS group and 91.5% (43/47 patients) in the 5000-cS group.

The mean changes in visual acuity from within 2 days before to 1 month after removal of the silicone oil in the 3700-cS group and the 5000-cS group were not significantly different (13/100 vs 15/100) (**Table I**). The decrease in intraocular pressure was not significantly different between groups (1.20 and 2.33 mm Hg, respectively).

The mean (SD) increase in axial length was not significantly different in the 3700-cS group compared with the 5000-cS group (11.92 [1.97] vs 12.33 [1.28] mm). Mean refraction decreased significantly in the 3700-cS group compared with the 5000-cS group (5.80 [1.51] vs 6.88 [2.31] D; $t = 2.57$; $P < 0.05$) (**Table II**).

The majority of the recurrent RDs occurred within 3 months of oil removal. The causes of redetachment were redevelopment of PVR (5 eyes) and residual traction (2).

Table I. Indicators of visual acuity before and after removal of the silicone oil following retinal attachment surgery in Chinese patients (n = 89 eyes). Data are mean (SD) no. (%).

	3700-cS Group		5000-cS Group	
Visual Acuity	Before Silicone Oil Removal	After Silicone Oil Removal*	Before Silicone Oil Removal	After Silicone Oil Removal*
LP	2 (4.76)	0	2 (4.25)	0
HM	19 (45.24)	4 (9.52)	20 (42.55)	6 (12.76)
CF	17 (40.48)	7 (16.67)	19 (40.43)	9 (19.15)
2/100–5/100	2 (4.76)	11 (26.19)	4 (8.51)	12 (25.53)
5/100–4/40	2 (4.76)	15 (35.71)	2 (4.25)	16 (34.04)
4/40–8/20	0	5 (11.90)	0	4 (8.51)
χ^2	37.12		31.99	

cS = centistoke; LP = light perception; HM = hand motion; CF = counting fingers at a distance of 10 to 50 cm.

*Overall, $P < 0.01$ after oil removal versus before oil removal.

Table II. Change in axial length and refraction in patients after silicone oil removal following retinal attachment surgery in Chinese patients (n = 89 eyes). Data are mean (SD).

Variable	3700-cS Group	5000-cS Group	*t* Test	*P*
Axial length, mm	11.92 (1.97)	12.33 (1.28)	1.18	NS
Refraction, D	5.80 (1.51)	6.88 (2.31)	2.57	<0.05

cS = centistoke; D = diopter.

DISCUSSION

Since the invention of vitrectomy instruments, the role of silicone oil as a vitreous substitute for retinal tamponade has expanded. The beneficial effect of silicone oil was confirmed in a multicenter clinical trial.[8] Although silicone oil has been found useful in treating complicated RDs, the question of the preferred viscosity for use in the clinical setting remains unanswered.[3] The most frequently used silicone oils are highly purified polydimethylsiloxanes with viscosities from 100 to 12,500 cS; however, silicone oils with a viscosity of 3700 to 5000 cS are currently used in most vitreoretinal surgeries.[9]

Silicone oil instillation into the eye produces a marked hyperopic shift in refraction because it has a higher refractive index than the vitreous alone. This change varies with the state of the lens and the percentage of the vitreous cavity filled by the silicone oil. In phakic eyes, a mean shift of 5.57 D occurs in a spherical equivalent, while a mean shift of –6.70 D occurs in aphakic eyes. In pseudophakic eyes, the change depends on the type of intraocular lens used.[10] Additionally, incomplete silicone oil instillation into the vitreous cavity may result in a refractive deviation due to movement of the silicone oil and curvature change of the intraocular silicone oil surface. Accordingly, the degree of the refractive change depends on the position of the head and the viscosity of the oil.[11] In our study, several factors that might have affected refraction and axial length were excluded, as we included only aphakic patients.

The clear-cornea technique is well known and associated with the smallest refractive change in cataract surgery. In our study, both the 3700- and 5000-cS silicone oils were removed via clear-corneal incision. Clear and stable vitreous cavities were maintained without any postoperative leakage, and there were no operative or postoperative complications related to this procedure in any of the cases. Overall, visual acuity improved in 37.2% of the eyes in our study after silicone oil removal. Elimination of the variability in refraction induced by the anterior curve of the silicone oil bubble and light diffraction induced by droplets of emulsified oil may have rendered the eye more responsive to optical correction.

In this study, the overall redetachment rate was 7.9% (7 eyes), which is similar to the findings of other studies of silicone oil removal.[12] The redetachment rate was numerically higher in the 5000-cS silicone oil group than in the 3700-cS group. The causes of redetachment were mostly redevelopment of PVR and residual traction. The use of 5000-cS oil in more complex cases might be another possible explanation for

our observation.[13] In silicone-filled eyes, the axial length measurement appears longer than in eyes that are not filled with silicone because ultrasound velocity is delayed by the silicone. In cases in which the vitreous space is not completely replaced with silicone oil, the amount of oil that the ultrasound beam transverses depends on the position in which the patient is placed during measurement and the viscosity of the oil, resulting in variable axial length measurements.[14] Accomplishing a stable, reattached retina is the final goal of all retinal surgeons. The possibility of achieving this goal might be increased with the use of higher-viscosity silicone oil for longer periods, especially in complex forms of RD.

CONCLUSIONS

A statistically significant decrease in refraction was found in the 3700-cS group compared with the 5000-cS group in these Chinese patients who underwent vitreoretinal surgery and instillation of silicone oil. There were no other statistically significant differences between the 2 groups.

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